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(54) Abstract Title
Treating waste material

(57) Apparatus for deodorising and neutralising pathogens in sewage sludge comprises an auger mixer 2 in which sludge from an infeed auger conveyor 8 is mixed with quicklime metered through metering auger 12 from silo 11. The sludge and quicklime are mixed in auger mixer 2 for one to two minutes to cause an exothermic reaction raising the temperature of the mixture to approximately 90°C and the pH of the mixture to approximately 12. Solid matter in the mixture is reduced (see Fig. 2, means 30) to a particle size not exceeding 5 cm., and is fed to a rotary dryer 3 where the temperature of the mixture is raised to approximately 400°C by a heated air stream from fan burner unit 40. The mixture is tumbled in drum 32 for seven to ten minutes and treated material discharged onto output conveyor 50. Other types of waste material may be treated and other sources of calcium oxide may be used. A process using the apparatus is also claimed.

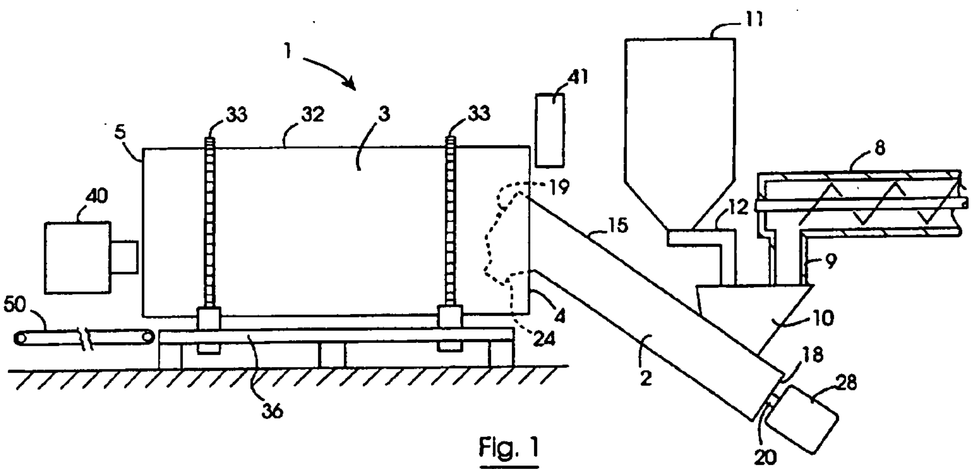

Fig. 1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

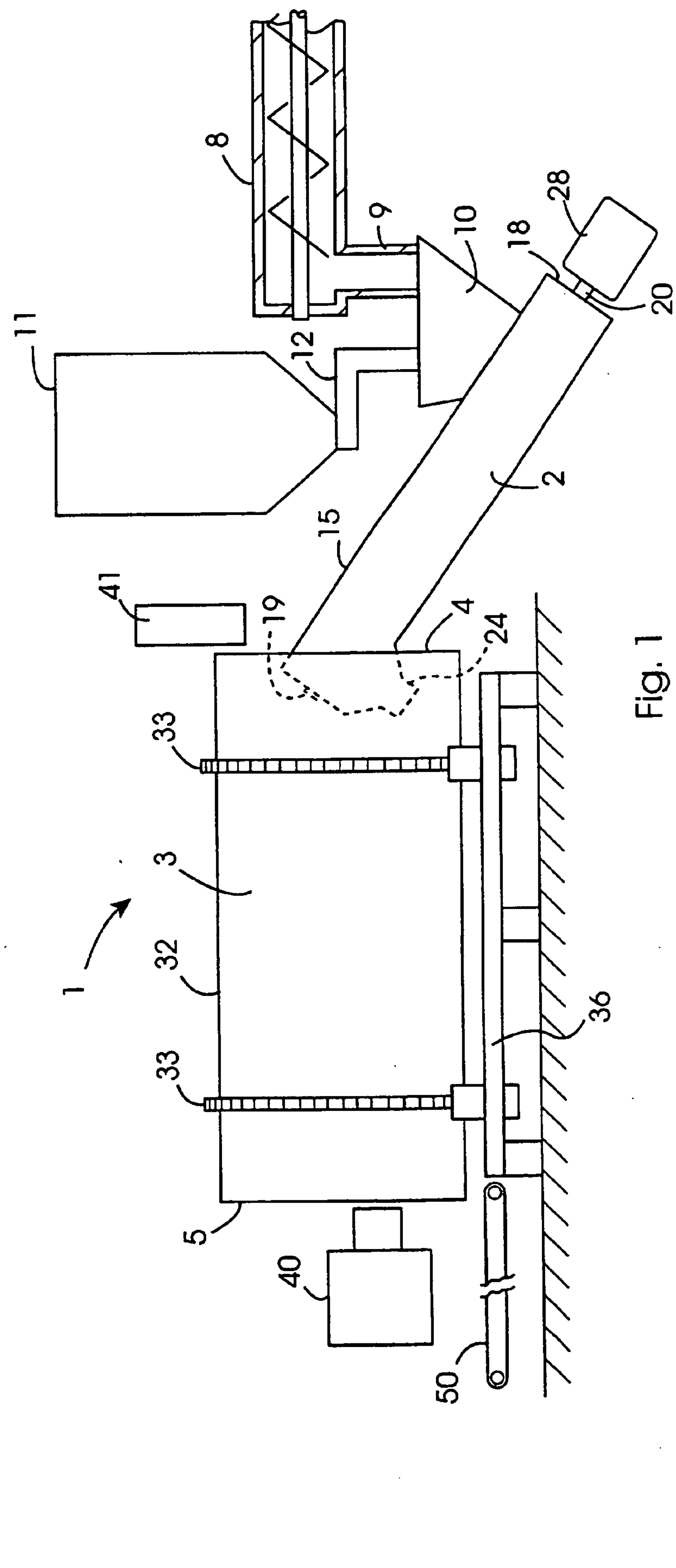

Fig. 1

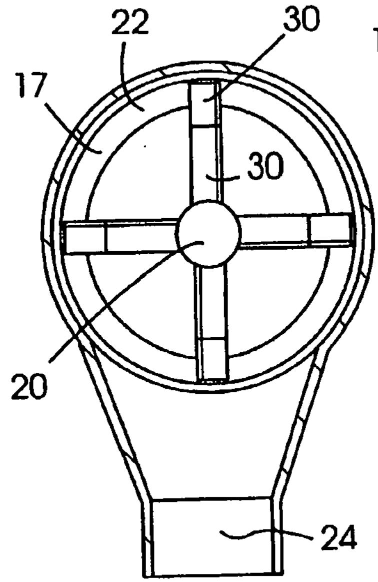
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Fig. 3

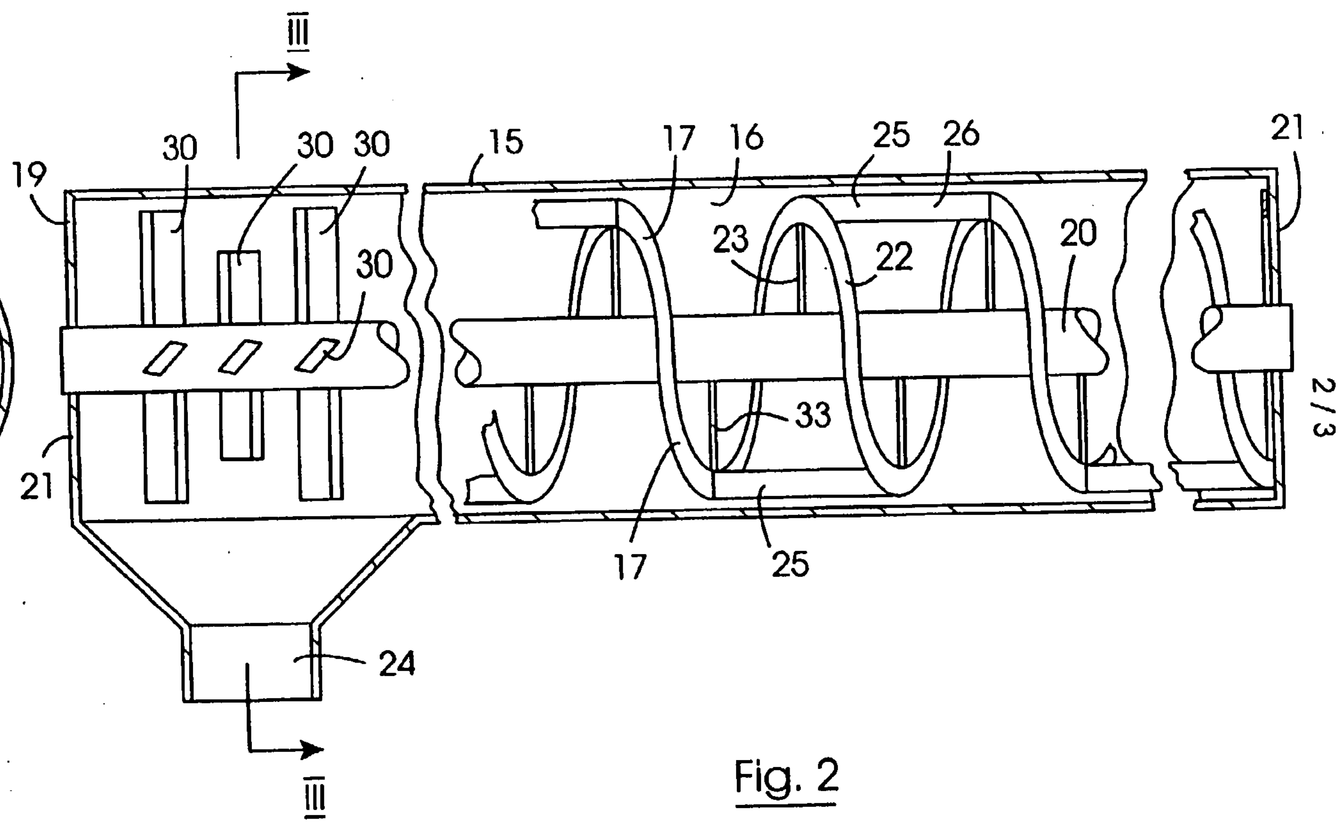
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Fig. 2

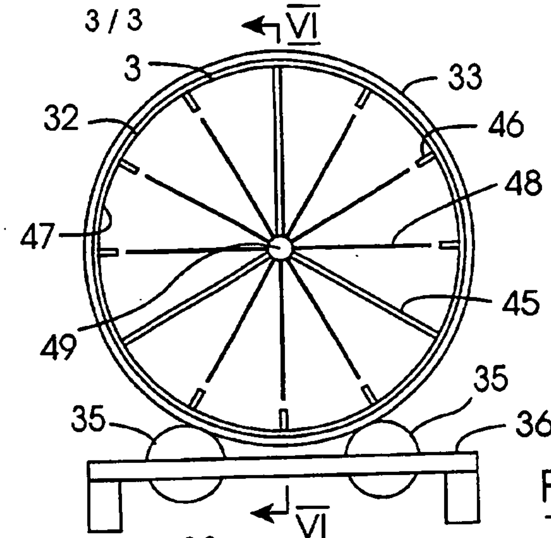

Fig. 4

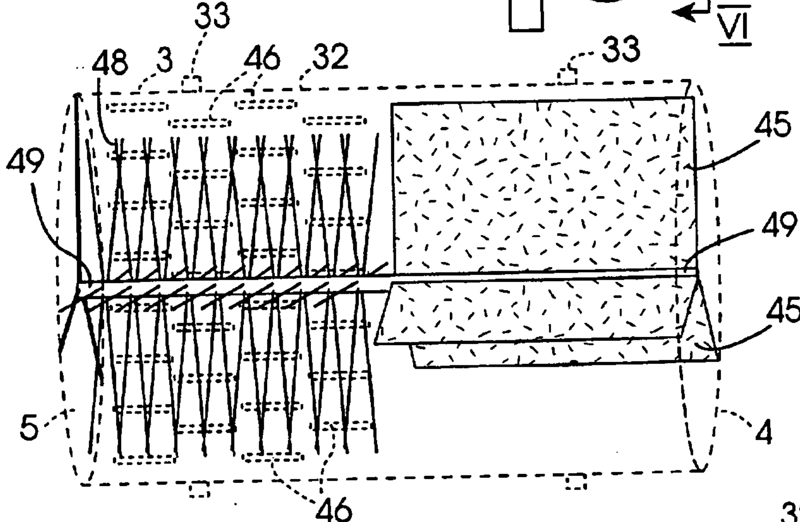

Fig. 6

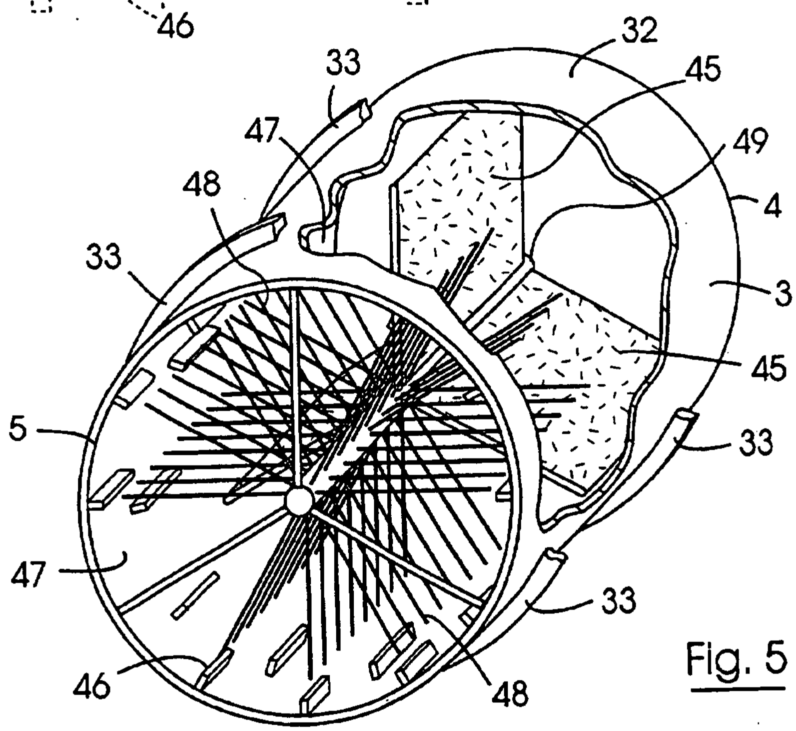

Fig. 5

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"A process and apparatus for treating waste material"

The present invention relates to a process and apparatus for treating waste material, and in particular, though not limited to a process and apparatus for treating sewage waste in sludge form.

Untreated waste material, in particular, sewage waste may contain, and indeed in general contains substances which are hazardous to humans and the environment, these substances may include organic and inorganic compounds, pathogens and particulate solids. Thus, it is desirable to treat such waste materials, and in particular, sewage prior to disposal. Various processes and apparatus are known for the treatment of such waste sludge materials. In one known process to kill pathogens in sewage sludge, the sludge is heated to a high temperature for an extended period of time. The heating process is generally referred to as pasteurisation and the degree to which the pathogens within the sludge are killed or neutralised is largely dependent upon the temperature levels employed and the residence time of the waste material at the elevated temperature. In general, in the pasteurisation process the sewage sludge is heated to a temperature of approximately 70°C for periods of two and a half hours and upwards. Indeed, in many cases time periods considerably in excess of two and a half hours are required, and thus, pasteurisation tends to be a relatively time consuming process.

However, pasteurisation alone in general, is ineffective in neutralising the odours which may emanate from waste materials, and in particular, from sewage sludge. Unfortunately, the odours from sewage sludge have a tendency to attract vectors, such as vermin, namely, rats, mice and the like, and insects, such as flies, fleas and the like which in turn can pose a health risk by acting as carriers for any remaining pathogens and other hazardous substances remaining in the sewage sludge after it has been pasteurised. Apart from the health risks which residual odours in sewage sludge can lead to, for example, the attraction of vectors and the like, residual odours in pasteurised sewage sludge are also objectionable.

It is well known that sewage sludge is high in minerals and other substances which have beneficial effects as fertilisers in the growing of crops, plants and the like when spread on land. However, because of the objectionable odour, it is not feasible to spread pasteurised sludge on land. Deodorising processes for treating sewage sludge are known, however, they tend to suffer from disadvantages. One process for deodorising sewage sludge is to add quicklime to the sludge for elevating the pH of the sludge which tends to stabilise the sludge and reduce the odour. However, such known methods of treating sludge whereby the sludge is pasteurised and treated with quicklime tend to be relatively time consuming and costly, and in general, do not satisfactorily remove the odour.

A further difficulty in the treatment of sewage sludge is that the consistency of the sludge can vary vastly, from a relatively liquid consistency to a substantially solid consistency. Furthermore, the sewage typically is made up of solid and liquid components, and in general, the solid components comprise a bound liquid, typically water, and thus, where the sewage sludge comprises a high degree of water, the water may be made up a free liquid component as well as the bound liquid component. While the free liquid component in general, can be removed by a dewatering step in the process, nevertheless dewatered sludge may have varied solids content and the solids may be of varying sizes. Accordingly, even dewatered sludge may have vastly different physical characteristics which may vary from a viscous, colloidal liquid to a dry cake or clay. Because of this, known processes and apparatus for treating sewage sludge in general, are unsatisfactory due to the fact that they tend to be relatively time consuming processes, and in general, have a relatively high energy requirement and do not adequately remove odours.

There is therefore a need for a process and apparatus for treating sewage sludge for reducing pathogen and odour levels of the sludge. Indeed, there is a need for a process and apparatus for treating many waste materials for reducing the pathogen and odour levels thereof.

The present invention is directed towards providing such a process and apparatus.

According to the invention there is provided a process for treating waste material comprising mixing the waste material with an additive for causing an exothermic reaction in the mixture and for raising the pH of the mixture, aerating and reducing the particle size of the mixture and dehydrating the mixture.

In one embodiment of the invention the additive for causing the exothermic reaction and for raising the pH of the mixture comprises substances containing calcium oxide.

In another embodiment of the invention the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is selected from a group comprising lime, quicklime, dolomitic lime, cement kiln dust and lime kiln dust.

In a further embodiment of the invention the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is added to the waste material in an amount sufficient for causing the temperature of the mixture to rise to at least 70°C, and preferably to 75°C, and advantageously to at least 80°C, and ideally to at least 90°C.

In one embodiment of the invention the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is added to the waste material in an amount sufficient for raising the pH of the mixture to a pH of at least 8, and preferably to a pH of at least 10, and advantageously to a pH of at least 12.

In another embodiment of the invention the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is mixed with the waste material for a time sufficient for causing the temperature of the mixture to raise to at least 70°C, and preferably to at least 75°C, and advantageously to at least 80°C, and ideally to at least 90°C.

In a still further embodiment of the invention the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is mixed with the waste material for a time sufficient for raising the pH of the mixture to a pH of at least 8, and preferably, to a pH of at least 10, and ideally to a pH of at least 12.

In one embodiment of the invention the mixture is mixed for a time period of at least 1 minute, and preferably for a time period of approximately 2 minutes.

In one embodiment of the invention the mixture is mixed in an auger mixer.

In another embodiment of the invention the mixture is aerated during mixing.

In a further embodiment of the invention the mixture is hydrated after mixing, and preferably, is aerated during mixing.

In one embodiment of the invention the particle size of the mixture is reduced after mixing by subjecting the mixture to a chopping operation.

Preferably, the chopping operation is carried out by subjecting the mixture to the action of chopping blades.

Advantageously, the mixture is subjected to the chopping action on exiting the mixer.

In one embodiment of the invention the mixture is dehydrated in a rotary dryer.

In another embodiment of the invention a hot air stream is directed through the rotary dryer, and the temperature of the hot air stream is at least 120°C. Preferably, the temperature of the hot air stream through the rotary dryer is in the range of 120°C to 600°C. Advantageously, the temperature of the hot air stream through the rotary dryer is in the range of 300°C to 550°C. Preferably, the temperature of the hot air stream through the rotary dryer is in the range of 300°C to 400°C, and ideally the temperature of the hot air stream through the rotary dryer is in the order of 400°C.

In one embodiment of the invention the hot air stream is passed through the rotary dryer in contra flow relative to the flow of mixture through the rotary dryer.

In one embodiment of the invention the mixture is subjected to dehydration until the moisture content of the dehydrated mixture is in the range of 5% to 45% by weight of the mixture. Typically, the mixture is subjected to dehydration until the moisture content of the dehydrated mixture is in the range of 5% to 35% by weight of the mixture.

In one embodiment of the invention the mixture is subjected to dehydration for a time period in the range of 5 minutes to 15 minutes, and advantageously, for a time period in the range of 7 minutes to 10 minutes.

In one embodiment of the invention the moisture content of the waste material prior to mixing with the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is in the range of 75% to 95%.

In another embodiment of the invention the moisture content of the waste material prior to mixing with the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is in the range of 80% to 90%.

In another embodiment of the invention the moisture content of the waste material prior to mixing with the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is in the range of 85% to 88%.

In one embodiment of the invention the waste material is in sludge form.

In another embodiment of the invention the waste material is sewage.

In a still further embodiment of the invention the waste material is sewage sludge.

Additionally, the invention provides apparatus comprising a mixing means for mixing the waste material with an additive for causing an exothermic reaction in the mixture and for raising the pH of the mixture, a means for reducing the particle size of the mixture, and a means for dehydrating the mixture.

In one embodiment of the invention the mixing means comprises an elongated auger mixer. Preferably, the auger mixer comprises an elongated cylindrical housing.

Advantageously, the auger mixer comprises an auger screw which defines a rotational axis, and which is located within the housing.

In one embodiment of the invention the auger screw is formed by a ribbon auger carried on and extending around a main carrier shaft, and spaced apart therefrom. Preferably, the ribbon auger is carried on the main carrier shaft by a plurality of spaced apart radially extending spokes extending radially from the main carrier shaft to the ribbon auger.

In another embodiment of the invention a plurality of mixing paddles are provided along the auger screw, each mixing paddle extending from one 360° segment of the auger screw to an adjacent 360° segment.

Advantageously, each mixing paddle presents a radially axially extending face to the mixture as the auger screw is being rotated.

Preferably, each mixing paddle extends substantially axially between the respective adjacent 360° segments of the auger screw, and is located towards the peripheral edges thereof.

In one embodiment of the invention the mixing means is inclined upwardly from an upstream end for receiving the waste material and the additive to a downstream end from which the mixed material is discharged.

In another embodiment of the invention a dispensing means is provided for dispensing the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture into the waste material. Preferably, the dispensing means comprises a metering means for metering the additive into the waste material as the waste material is being fed to the mixing means.

Advantageously, the dispensing means is located at the upstream end of the mixing means.

In another embodiment of the invention the dehydrating means comprises a drying means.

Preferably, drying means comprises a rotary dryer.

Advantageously, the rotary dryer comprises an elongated rotatable drying drum within which the mixture is dried, the drying drum defining a main rotational axis and having an upstream end for receiving the mixture of additive and waste material and a downstream end from which the dehydrated mixture is discharged.

Ideally, a tumbling means is located within the drying drum for tumbling the mixture within the drying drum as the drying drum rotates.

In one embodiment of the invention the tumbling means comprises at least one panel of mesh material extending radially from an inner surface of the drying drum. Preferably, each panel of mesh material extends to a position adjacent the main rotational axis of the drying drum.

Advantageously, the panels of mesh material are joined along the main rotational axis of the drum.

Preferably, three panels of mesh material are located equi-spaced circumferentially around the drum.

Ideally, each panel of mesh material extends in an axial direction along the inner surface of the drying drum.

Preferably, each panel of mesh material is located adjacent the upstream end of the drying drum.

In one embodiment of the invention each panel of mesh material extends substantially along half the axial length of the drum.

In one embodiment of the invention each panel of mesh material defines a plurality of perforations, and each perforation is of size such that its minimum dimension lies in the range of 1cm to 10cms. Preferably, the minimum dimension of each perforation in each panel lies in the range of 3cms to 7cms, and ideally is approximately 5cms.

In one embodiment of the invention the tumbling means comprises a plurality of axially extending blades extending inwardly from the inner surface of the drying drum.

Preferably, the tumbling blades are spaced apart circumferentially around the drum.

Advantageously, the tumbling blades extend radially from the inner surface of the drying drum.

Ideally, the tumbling blades are located in a downstream portion of the drying drum.

In one embodiment of the invention the tumbling blades are located in the downstream half of the drying drum.

In another embodiment of the invention the tumbling means comprises a plurality of tumbling members extending from a main support shaft of the drying drum disposed within the drying drum and co-axial with the drying drum.

Preferably, the tumbling members are spaced apart circumferentially and axially along the main support shaft.

Advantageously, the tumbling members extend radially from the main support shaft.

Ideally, each tumbling member is of rectangular cross-section and is arranged to have an auger type action on the mixture within the drying drum.

In a further embodiment of the invention the auger type action of the tumbling members acts in a direction for urging the mixture in a direction towards the downstream end of the drum.

In another embodiment of the invention the tumbling blades and the tumbling members co-operate for tumbling the mixture in the drying drum.

In a further embodiment of the invention the drying drum is inclined downwardly to the horizontal from the upstream end to the downstream end. Preferably, the angle of inclination of the drying drum to the horizontal from the upstream end to the downstream end is in the range of 1° to 10°. Advantageously, the angle of inclination of the drying drum to the horizontal from the upstream end to the downstream end is in the range of 3° to 7°. Ideally, the angle of inclination of the drying drum to the horizontal from the upstream end to the downstream end is in the range of approximately 5°.

In one embodiment of the invention a hot air stream generating means is provided for directing a hot air stream through the drying drum for drying of the mixture therein.

Preferably, the hot air stream generating means is located relative to the drying drum for directing the hot air stream in contra flow to the direction of flow of mixture through the drum.

Advantageously, the hot air stream generating means comprises a burner unit located at the downstream end of the drying drum.

In one embodiment of the invention the means for reducing the particle size of the mixture comprises a chopping means. Advantageously, the chopping means comprises a plurality of chopping blades located at the downstream end of the

mixing means for chopping the mixture prior to delivery into the dehydrating means. Advantageously, the chopping means comprises a plurality of chopping blades mounted on the downstream end of the main carrier shaft of the auger mixer.

In one embodiment of the invention the apparatus is suitable for treating a sludge material.

In another embodiment of the invention the apparatus is suitable for treating sewage material in sludge form.

The advantages of the invention are many. One of the most important advantages of the invention is that it provides an apparatus and process for treating waste material such that the treated material is effectively free of pathogens and other hazardous substances, and is virtually free of odour. This is a particularly important advantage in the treatment of sewage sludge. Another advantage of the invention is that the treatment time required for treating the waste material is relatively short. The mixing of the sewage sludge with quicklime takes approximately one to two minutes, while the drying takes approximately seven to ten minutes. Accordingly, the total processing time ranges from eight minutes to twelve minutes. This is a significantly important advantage in that it leads to an effective efficient and relatively low energy process for the treatment of sewage sludge. The relatively short processing time required for treating sewage sludge, and other waste materials using the process according to the invention is achieved, it is believed by a number of factors. Firstly, by breaking up the sewage sludge into particles of relatively small size facilitates in drying of the particles, and furthermore, it enhances the exothermic reaction between the quicklime and the sewage sludge. This, also reduces the time and the heat required for raising the temperature of the mixture of sewage sludge and quicklime since more efficient use is made of the exothermic action of the quicklime. Furthermore, by breaking up the particles of sewage into relatively small particles enhances aeration of the particles during the dehydration part of the process which further facilitates in the killing off and neutralising of pathogens and other hazardous substances in the sewage sludge. It has been found that the treated sewage sludge treated by the process and apparatus according to the invention is relatively stable,

and remains so. Indeed, it has been found that the pH of the treated material remained at 12 for approximately seven days after processing. It is believed that the combination of the use of quicklime and the dehydration of the mixture of sewage sludge and quicklime at a relatively high temperature range of 300°C to 550°C, and in particular at approximately 400°C plays a significant part in the stabilisation of the treated material, and thus in its deodorisation.

The invention will be more clearly understood from the following description of a preferred embodiment thereof which is given by way of example only with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatic representation of apparatus according to the invention for treating waste material,

Fig. 2 is a side elevational view of a portion of the apparatus of Fig. 1,

Fig. 3 is a cross-sectional end elevational view of the portion of the apparatus of Fig. 2 on the line III-III of Fig. 2,

Fig. 4 is an end elevational view of another portion of the apparatus of Fig. 1,

Fig. 5 is a cutaway perspective view of the portion of the apparatus of Fig. 4, and

Fig. 6 is a front perspective view of the portion of the apparatus of Fig. 4 illustrating the outer part of the portion in broken lines.

Referring to the drawings there is illustrated apparatus according to the invention indicated generally by the reference numeral 1 for continuously treating waste material, and in this embodiment of the invention for treating sewage sludge for killing or neutralising pathogens in the sewage sludge and for reducing or eliminating odours in the sewage sludge. The apparatus 1 comprises a mixing means, namely, an auger mixer 2 for mixing an additive, in this embodiment of the invention

quicklime as will be described below with the sewage sludge for causing an exothermic reaction in the mixture of sludge and quicklime for raising the temperature of the mixture and for raising the pH of the mixture, preferably, to a pH of 12, as will also be described below. A means for dehydrating the mixture of sewage sludge and quicklime after it has been thoroughly mixed in the mixer 2 comprises a rotary dryer 3 in which the temperature of the mixture is raised to approximately 400°C for a residence time in the range of seven to ten minutes as will be described below. The mixer 2 feeds the mixture of sludge and quicklime into the rotary dryer 3 at the upstream end 4 thereof, and the treated dehydrated material is delivered from the rotary dryer 3 at a downstream end 5. It has been found that the moisture content of the treated material lies between 5% and 35% by weight, and in general, is in the order of 20% by weight, the pathogens in the treated material have been neutralised and the odour virtually entirely removed.

The sewage sludge with a moisture content in the range of 85% to 88% is fed to the apparatus on an auger conveyor 8. An outlet 9 from the auger conveyor 8 delivers the sewage sludge into an upstream hopper 10 of the auger mixer 2. Quicklime is stored in a vertical silo 11 and is dispensed through a metering means, namely, a volumetric metering auger 12 from the silo 11 to the hopper 10. The metering auger 12 from the silo 11 is set to meter the quicklime into the sewage sludge at a rate to provide a mix of sewage sludge and quicklime in the ratio of approximately 20% quicklime to 80% sewage sludge by volume.

Referring in particular to Fig. 2, the auger mixer 2 comprises a cylindrical housing 15 which defines an elongated auger accommodating bore 16 for accommodating an auger screw 17. The housing 15 inclines upwardly from an upstream end 18 of the auger mixer 2 to a raised downstream end 19 of the auger mixer 2 at an angle of approximately 45° to the horizontal. The auger screw 17 comprises a main carrier shaft 20 which is rotatable in bearings (not shown) in respective end caps 21 at the axial opposite ends of the housing 15. A ribbon flight 22 of flat stock steel extends around and is spaced apart from the main carrier shaft 20 and is carried on the shaft 20 by radiallly extending spokes 23. The ribbon flight as well as acting to urge the mixture of quicklime and sewage sludge along the auger mixer 2 also acts to mix the

quicklime with the sewage sludge. A downstream outlet 24 feeds the mixture of sewage sludge and quicklime into the upstream end 4 of the rotary dryer 3. A plurality of mixing paddles 25 extend axially between respective adjacent 360° segments of the auger flight 22 for further enhancing mixing of the sewage sludge and quicklime in the mixer 2. The mixing paddles 25 are of relatively flat stock steel and are of radial width substantially similar to the radial width of the ribbon flight 22. The mixing paddles 25 are arranged to present a radially axially extending abutment face 26 to the mixture for mixing thereof as the auger screw 17 is rotating. An electrically powered motor 28 carried on the housing 15 by mounting brackets (not shown) drives the auger screw 17.

A means for reducing the particle size of the mixture of sewage sludge and quicklime prior to it being delivered into the rotary dryer 3 comprises a chopping means, namely, a plurality of chopping blades 30 which are carried on the main carrier shaft 20 at the downstream end thereof and extend radially therefrom. The chopping blades are of relatively flat stock steel welded to the main carrier shaft 20 and are arranged at a helical angle to the shaft 20, as can be seen in Fig. 2. It has been found that as the main carrier shaft 20 rotates the action of the chopping blades 30 on the mixture exiting from the auger screw 17 is sufficient for significantly reducing the particle size of the particle matter in the mixture, and in this embodiment of the invention reduces the particle size of the mixture such that the maximum dimension of the particles does not exceed 5cms.

The rotary dryer 3 comprises an elongated drying drum 32 extending between the upstream end 4 and the downstream end 5. A pair of spaced apart bearing rings 33 extend around the drum 32 for supporting the drum 32 on four rollers 35. One of the bearing rings 33 rests on one pair of rollers 35, while the other bearing ring 33 rests on the other pair of rollers 35. One roller 35 of each pair of rollers 35 is a driven roller for rotating the drum 32, while the other roller of each pair of rollers 35 is an idler roller. The rollers 35 are carried on shafts (not shown) which are rotatably carried in a base frame 36. In this embodiment of the invention the base frame 36 mounts the drum 32 so that the drum 32 inclines downwardly from the upstream end 4 to the downstream end 5 at an angle of approximately 5° to the horizontal. Stationery end

caps (not shown) close the drum 32 at its respective axially opposite ends. An inlet (not shown) is provided in the upstream end cap (not shown) for accommodating the downstream outlet 24 of the auger mixer 2 for feeding the chopped mixture of sewage sludge and quicklime into the drum 32 at the upstream end 4 thereof. A downstream outlet (also not shown) at the lower end of the end cap (not shown) at the downstream end 5 of the rotary dryer 3 delivers the treated material from the drum 32.

A means for generating a stream of hot air, namely, a fan and burner unit 40 is located at the downstream end of the rotary dryer 3, and delivers a heated stream of air through the drum 32 from the downstream end 5 to the upstream end 4 in contra flow to the direction of flow of the mixture of sewage sludge and quicklime. A dust extractor filter unit 41 at the upstream end 4 of the rotary dryer 3 exhausts and filters air and dust from the drum 32.

Referring now in particular to Figs. 4 to 6, the drum 32 comprises a tumbling means which is provided in three forms, namely, three mesh panels 45, a plurality of tumbling blades 46 located on an inner surface 47 of the drum 32, and a plurality of tumbling members 48 extending radially from a main support shaft 49 of the drum 32 for tumbling the particulate mixture of sewage sludge and quicklime within the drum 32. The three mesh panels 45 extend radially from the main support shaft 49 and are equi-spaced circumferentially around the main shaft 49 at 120° intervals for causing initial tumbling of the mixture of sludge and quicklime in the drum 32. The mesh panels 45 extend radially from the main shaft 49 to the inner surface 47 of the drum 32 and extend axially from a position approximately half way between the upstream and downstream ends 4 and 5 of the drum 32 upstream towards the upstream end 4. However, although not illustrated in Figs. 5 and 6 the mesh panels 45 stop short of the upstream end 4 a distance sufficient to provide clearance for the downstream outlet 24 of the auger mixer 2. The mesh panels 45 are of expanded metal mesh material with a minimum dimension of each perforation being approximately 5cms for accommodating the largest size particle of the sewage sludge quicklime mixture. The tumbling blades 46 are elongated blades and extend axially along and radially inwardly from the inner surface 47, and are provided along the drum 32 between the

upstream and downstream ends 4 and 5. The tumbling blades 46 are equi-spaced circumferentially around the inner surface 47 of the drum 32, and are spaced apart axially, as well as being staggered circumferentially. For convenience only some of the tumbling blades 46 are illustrated in Figs. 5 and 6. The tumbling members 48 are of relatively flat stock steel, and extend radially outwardly from the main support shaft 49 and stop short of the tumbling blades 46. The tumbling members 48 are arranged at a helical angle on the main support shaft 49 for urging the particulate mixture in a downstream direction.

An output conveyor 50 feeds the treated material from the outlet (not sown) of the rotary dryer 3 to a location where it may be bulk packed, bagged, pelletised or the like.

The use of the apparatus 1 for carrying out the process according to the invention for treating sewage sludge will now be described. The sewage sludge with a moisture content of approximately 85% to 88% by weight and a solids content in the order of 12% to 16% is continuously fed on the auger conveyor 8 into the hopper 10, and simultaneously the quicklime is continuously metered from the silo 11 by the metering auger 12. The ratio of quicklime to sewage sludge depends on the moisture content of the sludge, and is typically added in the ratio of 0.1 to 0.3 parts quicklime to one part of sludge by volume. In practice, with a moisture content of the sewage sludge of the order of 85% to 88%, the ratio of quicklime to sewage sludge is approximately 0.2 parts quicklime to one part of sewage sludge. This, in general, is sufficient for raising the pH of the mixture of sewage sludge and quicklime to approximately 12. The quicklime is rapidly and thoroughly mixed with the sewage sludge in the auger mixer 2, and typically, the resident time of the mixture in the auger mixer 2 is between one minute and two minutes. The mixing of the quicklime with the sludge as well as raising the pH of the sludge to a pH of 12 also causes an exothermic reaction which rapidly raises the temperature of the mixture to 90°C, and in cases where the temperature is not raised to 90°C, the temperature reaches at least 70°, which is sufficient for subjecting the mixture to an initial brief pasteurisation step. During mixing of the sewage sludge and quicklime in the auger mixer 2 air is present for aeration of the mixture. Thus, the rate at which the sewage is fed into the

auger mixer 2 is controlled to ensure that an adequate supply of air is entrained in the mixture of sewage sludge and quicklime.

The mixture of sewage sludge and quicklime is subjected to the chopping action of the chopping blades 30 before being delivered through the downstream outlet 24 of the auger mixer 2. The action of the chopping blades 30 on the solid matter of the mixture is such as to reduce the particle size of the solid matter such that the maximum dimension of any particle does not exceed 5cms.

The chopped mixture of sewage sludge and quicklime is delivered from the downstream outlet 24 of the auger mixer 2 into the drum 32 of the rotary dryer 3 where it is tumbled and subjected to the heated air stream. The air is heated by the fan burner unit 40 to a temperature of approximately 400°C and is delivered through the drum 32 at a rate sufficient for raising the temperature of the mixture to approximately 400°C. The residence time required of the sewage sludge and quicklime mixture in the drum 32 in general, is in the order of seven minutes to ten minutes. This, largely depends on the moisture content of the sewage sludge being delivered into the hopper 10 of the auger mixer 2 and the final moisture content required for the treated material. In general, with a starting moisture content of the sewage sludge of the order of 85% to 88% it has been found that a residence time of ten minutes of the sewage sludge and quicklime mixture in the drum 32 is sufficient for producing treated material with a moisture content of approximately 15% to 20% by weight of dry matter.

Additionally, it has been found that a residence time in the order of ten minutes of the mixture of sewage sludge and quicklime in the drum 32 is sufficient for raising the temperature of the mixture to 400°C for a time period of approximately ten minutes. This, it has been found is sufficient for neutralising the pathogens and other hazardous substances in the sewage sludge.

Typically, the auger mixer 2 and the rotary dryer 3 has a capacity of approximately three to four tons of sewage sludge per hour on a continuous basis.

The exothermic reaction between the sewage sludge and the quicklime is caused as follows:

$$CaO+H_2O = Ca(OH)_2 + heat$$

where the heat facilitates the pasteurisation and deodorising of the mixture.

The treated material delivered from the downstream outlet 39 of the rotary dryer 3 has been found to be virtually odourless, and is suitable for many uses, for example, spreading on land as a fertiliser, as top soil, as a soil conditioner, for peat land restoration, structural soil applications, land reclamation and use in reforestation.

While quicklime has been described as the additive for causing the exothermic reaction and raising the pH of the sewage sludge, other suitable additives may be used, for example, any other calcium oxide containing substances, such as, for example, dolomitic lime, cement kiln dust, lime kiln dust, lime and the like. While the proportion of quicklime to sewage sludge has been described as being approximately 20% quicklime to 80% sewage sludge, it is envisaged that other suitable proportions may be used, and the proportions in general, will depend on the moisture content of the sewage sludge. A typical range of proportions of quicklime to sewage sludge would be approximately 5% quicklime to 95% sewage sludge to 30% quicklime to 70% sewage sludge.

Needless to say, while the apparatus and the process have been described for treating sewage sludge, the apparatus and process may be used for treating sewage in forms other than sludge, and also may be used for treating many other waste materials whether in sludge form or otherwise.

While the tumbling members of the drying drum have been described as being arranged in auger fashion, this is not necessary. It is also envisaged that the tumbling members may be sequentially arranged on the shaft to define an auger. Additionally, while the mixing auger has been described as being inclined at an angle of approximately 45° to the horizontal, it is envisaged that the mixing auger may be inclined at any suitable angle, and typically, may be inclined at an angle in

the range of 30° to 50°. It is also envisaged that the mixing paddles which extend axially between adjacent 360° segments of the flights may be dispensed with.

Claims

1. A process for treating waste material comprising mixing the waste material with an additive for causing an exothermic reaction in the mixture and for raising the pH of the mixture, aerating and reducing the particle size of the mixture and dehydrating the mixture.

2. A process as claimed in Claim 1 in which the additive for causing the exothermic reaction and for raising the pH of the mixture comprises substances containing calcium oxide.

3. A process as claimed in Claim 1 or 2 in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is selected from a group comprising lime, quicklime, dolomitic lime, cement kiln dust and lime kiln dust.

4. A process as claimed in any preceding claim in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is added to the waste material in an amount sufficient for causing the temperature of the mixture to rise to at least 70°C.

5. A process as claimed in any preceding claim in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is added to the waste material in an amount sufficient for causing the temperature of the mixture to rise to at least 75°C.

6. A process as claimed in any preceding claim in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is added to the waste material in an amount sufficient for causing the temperature of the mixture to rise to at least 80°C.

7. A process as claimed in any preceding claim in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is added

to the waste material in an amount sufficient for causing the temperature of the mixture to rise to at least 90°C.

8. A process as claimed in any preceding claim in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is added to the waste material in an amount sufficient for raising the pH of the mixture to a pH of at least 8.

9. A process as claimed in any preceding claim in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is added to the waste material in an amount sufficient for raising the pH of the mixture to a pH of at least 10.

10. A process as claimed in any preceding claim in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is added to the waste material in an amount sufficient for raising the pH of the mixture to 12.

11. A process as claimed in any preceding claim in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is mixed with the waste material for a time sufficient for causing the temperature of the mixture to raise to at least 70°C.

12. A process as claimed in any preceding claim in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is mixed with the waste material for a time sufficient for causing the temperature of the mixture to raise to at least 75°C.

13. A process as claimed in any preceding claim in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is mixed with the waste material for a time sufficient for causing the temperature of the mixture to raise to at least 80°C.

14. A process as claimed in any preceding claim in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is mixed with the waste material for a time sufficient for causing the temperature of the mixture to raise to at least 90°C.

15. A process as claimed in any preceding claim in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is mixed with the waste material for a time sufficient for raising the pH of the mixture to a pH of at least 8.

16. A process as claimed in any preceding claim in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is mixed with the waste material for a time sufficient for raising the pH of the mixture to a pH of at least 10.

17. A process as claimed in any preceding claim in which the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is mixed with the waste material for a time sufficient for raising the pH of the mixture to a pH of 12.

18. A process as claimed in any preceding claim in which the mixture is mixed for a time period of at least 1 minute.

19. A process as claimed in any preceding claim in which the mixture is mixed for a time period of approximately 2 minutes.

20. A process as claimed in any preceding claim in which the mixture is mixed in an auger mixer.

21. A process as claimed in any preceding claim in which the mixture is aerated during mixing.

22. A process as claimed in any preceding claim in which the mixture is hydrated after mixing.

23. A process as claimed in any preceding claim in which the particle size of the mixture is reduced after mixing by subjecting the mixture to a chopping operation.

24. A process as claimed in Claim 23 in which the chopping operation is carried out by subjecting the mixture to the action of chopping blades.

25. A process as claimed in Claim 24 in which the mixture is subjected to the chopping action on exiting the mixer.

26. A process as claimed in any preceding claim in which the mixture is dehydrated in a rotary dryer.

27. A process as claimed in Claim 26 in which a hot air stream is directed through the rotary dryer, and the temperature of the hot air stream is at least 120°C.

28. A process as claimed in Claim 27 in which the temperature of the hot air stream through the rotary dryer is in the range of 120°C to 600°C.

29. A process as claimed in Claim 27 or 28 in which the temperature of the hot air stream through the rotary dryer is in the range of 300°C to 550°C.

30. A process as claimed in any of Claims 27 to 29 in which the temperature of the hot air stream through the rotary dryer is in the range of 300°C to 400°C.

31. A process as claimed in any of Claims 27 to 30 in which the temperature of the hot air stream through the rotary dryer is in the order of 400°C.

32. A process as claimed in any of Claims 27 to 31 in which the hot air stream is passed through the rotary dryer in contra flow relative to the flow of mixture through the rotary dryer.

33. A process as claimed in any preceding claim in which the mixture is subjected to dehydration until the moisture content of the dehydrated mixture is in the range of 5% to 45% by weight of the mixture.

34. A process as claimed in any preceding claim in which the mixture is subjected to dehydration until the moisture content of the dehydrated mixture is in the range of 5% to 35% by weight of the mixture.

35. A process as claimed in any preceding claim in which the mixture is subjected to dehydration for a time period in the range of 5 minutes to 15 minutes.

36. A process as claimed in any preceding claim in which the mixture is subjected to dehydration for a time period in the range of 7 minutes to 10 minutes.

37. A process as claimed in any preceding claim in which the moisture content of the waste material prior to mixing with the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is in the range of 75% to 95%.

38. A process as claimed in any preceding claim in which the moisture content of the waste material prior to mixing with the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is in the range of 80% to 90%.

39. A process as claimed in any preceding claim in which the moisture content of the waste material prior to mixing with the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture is in the range of 85% to 88%.

40. A process as claimed in any preceding claim in which the waste material is in sludge form.

41. A process as claimed in any preceding claim in which the waste material is sewage.

42. A process as claimed in any preceding claim in which the waste material is sewage sludge.

43. A process for treating waste material, the process being substantially as described herein with reference to and as illustrated in the accompanying drawings.

44. Apparatus for treating waste material, the apparatus comprising a mixing means for mixing the waste material with an additive for causing an exothermic reaction in the mixture and for raising the pH of the mixture, a means for reducing the particle size of the mixture, and a means for dehydrating the mixture.

45. Apparatus as claimed in Claim 44 in which the mixing means comprises an elongated auger mixer.

46. Apparatus as claimed in Claim 45 in which the auger mixer comprises an elongated cylindrical housing.

47. Apparatus as claimed in Claim 45 or 46 in which the auger mixer comprises an auger screw which defines a rotational axis, and which is located within the housing.

48. Apparatus as claimed in Claim 47 in which the auger screw is formed by a ribbon auger carried on and extending around a main carrier shaft, and spaced apart therefrom.

49. Apparatus as claimed in any Claim 48 in which the ribbon auger is carried on the main carrier shaft by a plurality of spaced apart radially extending spokes extending radially from the main carrier shaft to the ribbon auger.

50. Apparatus as claimed in any of Claims 47 to 49 in which a plurality of mixing paddles are provided along the auger screw, each mixing paddle extending from one 360° segment of the auger screw to an adjacent 360° segment.

51. Apparatus as claimed in Claim 50 in which each mixing paddle presents a radially axially extending face to the mixture as the auger screw is being rotated.

52. Apparatus as claimed in Claim 50 or 51 in which each mixing paddle extends substantially axially between the respective adjacent 360° segments of the auger screw, and is located towards the peripheral edges thereof.

53. Apparatus as claimed in any of Claims 44 to 52 in which the mixing means is inclined upwardly from an upstream end for receiving the waste material and the additive to a downstream end from which the mixed material is discharged.

54. Apparatus as claimed in any of Claims 44 to 53 in which a dispensing means is provided for dispensing the additive for causing the exothermic reaction in the mixture and for raising the pH of the mixture into the waste material.

55. Apparatus as claimed in Claim 54 in which the dispensing means comprises a metering means for metering the additive into the waste material as the waste material is being fed to the mixing means.

56. Apparatus as claimed in Claim 54 or 55 in which the dispensing means is located at the upstream end of the mixing means.

57. Apparatus as claimed in any of Claims 44 to 56 in which the dehydrating means comprises a drying means.

58. Apparatus as claimed in Claim 57 in which the drying means comprises a rotary dryer.

59. Apparatus as claimed in Claim 58 in which the rotary dryer comprises an elongated rotatable drying drum within which the mixture is dried, the drying drum defining a main rotational axis and having an upstream end for receiving the mixture of additive and waste material and a downstream end from which the dehydrated mixture is discharged.

60. Apparatus as claimed in Claim 59 in which a tumbling means is located within the drying drum for tumbling the mixture within the drying drum as the drying drum rotates.

61. Apparatus as claimed in Claim 60 in which the tumbling means comprises at least one panel of mesh material extending radially from an inner surface of the drying drum.

62. Apparatus as claimed in Claim 61 in which each panel of mesh material extends to a position adjacent the main rotational axis of the drying drum.

63. Apparatus as claimed in Claim 61 or 62 in which the panels of mesh material are joined along the main rotational axis of the drum.

64. Apparatus as claimed in any of Claims 61 to 63 in which three panels of mesh material are located equi-spaced circumferentially around the drum.

65. Apparatus as claimed in any of Claims 61 to 64 in which each panel of mesh material extends in an axial direction along the inner surface of the drying drum.

66. Apparatus as claimed in any of Claims 61 to 65 in which each panel of mesh material is located adjacent the upstream end of the drying drum.

67. Apparatus as claimed in any of Claims 61 to 66 in which each panel of mesh material extends substantially along half the axial length of the drum.

68. Apparatus as claimed in any of Claims 61 to 67 in which each panel of mesh material defines a plurality of perforations, and each perforation is of size such that its minimum dimension lies in the range of 1cm to 10cms.

69. Apparatus as claimed in Claim 68 in which the minimum dimension of each perforation in each panel lies in the range of 3cms to 7cms.

70. Apparatus as claimed in Claim 69 in which the minimum dimension of each perforation in each panel is approximately 5cms.

71. Apparatus as claimed in any of Claims 60 to 70 in which the tumbling means comprises a plurality of axially extending blades extending inwardly from the inner surface of the drying drum.

72. Apparatus as claimed in Claim 71 in which the tumbling blades are spaced apart circumferentially around the drum.

73. Apparatus as claimed in Claim 71 or 72 in which the tumbling blades extend radially from the inner surface of the drying drum.

74. Apparatus as claimed in any of Claims 71 to 73 in which the tumbling blades are located in a downstream portion of the drying drum.

75. Apparatus as claimed in any of Claims 71 to 74 in which the tumbling blades are located in the downstream half of the drying drum.

76. Apparatus as claimed in any of Claims 60 to 75 in which the tumbling means comprises a plurality of tumbling members extending from a main support shaft of the drying drum disposed within the drying drum and co-axial with the drying drum.

77. Apparatus as claimed in Claim 76 in which the tumbling members are spaced apart circumferentially and axially along the main support shaft.

78. Apparatus as claimed in Claim 76 or 77 in which the tumbling members extend radially from the main support shaft.

79. Apparatus as claimed in any of Claims 74 to 76 in which each tumbling member is of rectangular cross-section and is arranged to have an auger type action on the mixture within the drying drum.

80. Apparatus as claimed in Claim 79 in which the auger type action of the tumbling members acts in a direction for urging the mixture in a direction towards the downstream end of the drum.

81. Apparatus as claimed in any of Claims 76 to 80 in which the tumbling blades and the tumbling members co-operate for tumbling the mixture in the drying drum.

82. Apparatus as claimed in any of Claims 59 to 81 in which the drying drum is inclined downwardly to the horizontal from the upstream end to the downstream end.

83. Apparatus as claimed in Claim 82 in which the angle of inclination of the drying drum to the horizontal from the upstream end to the downstream end is in the range of 1° to 10°.

84. Apparatus as claimed in Claim 83 in which the angle of inclination of the drying drum to the horizontal from the upstream end to the downstream end is in the range of 3° to 7°.

85. Apparatus as claimed in Claim 84 in which the angle of inclination of the drying drum to the horizontal from the upstream end to the downstream end is in the range of approximately 5°.

86. Apparatus as claimed in any of Claims 59 to 85 in which a hot air stream generating means is provided for directing a hot air stream through the drying drum for drying of the mixture therein.

87. Apparatus as claimed in Claim 86 in which the hot air stream generating means is located relative to the drying drum for directing the hot air stream in contra flow to the direction of flow of mixture through the drum.

88. Apparatus as claimed in Claim 86 or 87 in which the hot air stream generating means comprises a burner unit located at the downstream end of the drying drum.

89. Apparatus as claimed in any of Claims 44 to 88 in which the means for reducing the particle size of the mixture comprises a chopping means.

90. Apparatus as claimed in Claim 89 in which the chopping means comprises a plurality of chopping blades located at the downstream end of the mixing means for chopping the mixture prior to delivery into the dehydrating means.

91. Apparatus as claimed in any of Claims 89 to 90 in which the chopping means comprises a plurality of chopping blades mounted on the downstream end of the main carrier shaft of the auger mixer.

92. Apparatus as claimed in any of Claims 44 to 91 in which the apparatus is suitable for treating a sludge material.

93. Apparatus as claimed in any of Claims 44 to 92 in which the apparatus is suitable for treating sewage material in sludge form.

94. Apparatus for treating waste material, the apparatus being substantially as described herein with reference to and as illustrated in the accompanying drawings.

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Application No:	GB 9925858.4	**Examiner:**	Graham S. Lynch
Claims searched:	1 to 94	**Date of search:**	4 October 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): C1B (BBG); C1C (CJB, CJD, CKB, CKD, CLB, CLD)

Int Cl (Ed.7): B09B 3/00; B63J 4/00; C02F 11/00, 11/14

Other: On-line : WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 2248848 A	FORDER, BARRETT. Whole document.	1-3, 8-10, 18, 20-22, 44-47, 54, 57 at least.
Y	GB 1600901	NATUMIX. Whole document.	1-3, 8-10, 18, 20-22, 44-47, 54, 57 at least.
Y	GB 1560467	MANCHAK. Whole document.	1-3, 8-10, 18, 20-22, 44-47, 54, 57 at least.
Y	GB 1513651	THAMES WATER. Whole document.	1-3, 8-10, 18, 20-22, 44-47, 54, 57 at least.
Y	GB 462094	DORR. Whole document.	1-3, 8-10, 18, 20-22, 44-47, 54, 57 at least.
X	EP 0705795 A1	SCHLOBOHM. See whole document and accompanying abstract.	1, 44 at least.

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		

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Claims searched: 1 to 94

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Date of search: 4 October 2000

Category	Identity of document and relevant passage	Relevant to claims
Y	WO 98/29348 R3 MANAGEMENT. Whole document.	1-3, 8-10, 18, 20-22, 44-47, 54, 57 at least.
Y	US 5679262 GIROVICH et al. Whole document.	1-3, 8-10, 18, 20-22, 44-47, 54, 57 at least.
Y	US 5409605 HALEY et al. Whole document.	1-3, 8-10, 18, 20-22, 44-47, 54, 57 at least.
Y	US 5277825 TOBLER et al. Whole document.	1-3, 8-10, 18, 20-22, 44-47, 54, 57 at least.
X	US 4295972 KAMEI. Whole document.	44 at least.
X	US 4226712 KAMEI. Whole document.	44 at least.

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Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.